GONADS OF SKIPJACK FROM PALAO WATERS

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THE GONADS OF SKIPJACK FROM PALAO WATERS

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From September 1941 to January 1942 the author was engaged in a study of the brain of the skipjack at the Palau Tropical Biological Station. During this period he was also able to make some observations of the gonads of some of the skipjack which were taken there. He had hoped to clarify the annual changes in the gonads by making observations over a long period of time, but because of the short duration of his stay at Palau he was able to continue his observations for only three months. He trusts, however, that these observations will not be entirely without value at the present time when all sorts of knowledge about the skipjack are so much to be desired, and so, in spite of the brevity of his researches, he has decided to present his observations here. He will feel amply rewarded if they may be of some use as reference data for further study in this field.

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From the skipjack taken by the boats of the Nankō Fishing Company about 10 fish representing all sizes from the largest to the smallest were selected from each school for study. After the length and weight of the fish had been recorded the bellies were opened and the gonads removed. The length* and weight of the gonads were then determined. As will be shown below, in general the large skipjack had large gonads and the small skipjack had small gonads, but it was not only in the large fish that the gonads were in an advanced state of maturity. The gonads of some of the large fish were not in an advanced state of ripening, while some of the smaller fish had gonads which, although small, were ripe. There was no noticeable correlation between the size and ripeness of the gonads. (This fact is demonstrated by Figure 1.) For this reason a series of grades or degrees of ripeness was set up based on criteria which could be readily determined by examination. Some of the points on which these estimates were based were the number of blood vessels on the surface of the gonads, the roundness and distension of the gonads, and the degree to which the ova had taken shape. In the case of the testes the presence or absence of milt in the central lumen of the organ was one of the points on which judgments were based. The selection of these criteria was not based on a critical examination of the question of whether or not they were an accurate standard, but they are thought to be probably related to maturation and from the standpoint of practicality they are a convenient means for distinguishing degrees of ripeness. Based on these criteria four grades of maturity were established for the ovaries and three for the testes. The number of grades could have been further increased by finer divisions, but for observations based on the standards described above this seemed like an appropriate number of categories. There were, of course, gonads of a degree of maturity which fell between these categories, but they were few. The limits of the categories cannot be exactly defined here, but in general they were as follows:

Females

Grade 1. The ovaries as a whole are thin, and the blood vessels are not developed on the surface, which is smooth. The ova do not show as distinct grains.

Grade 2. Thicker than Grade 1, development of blood vessels perceptible on the surface, which shows diagonal folds (Figure 2, lower right).

Grade 3. Thicker than 2, folds further developed on the surface, purplish stripes appear along these folds (Figure 2, lower left).

Grade 4. Thickness further increased, surface distended, more numerous purple stripes (Figure 1).

*The lengths of the left and right gonad may differ. In such cases only the longest one was measured.

Males

Grade 1. White but still slender, blood vessels on the surface not developed, firm to the touch.

Grade 2. Thicker than 1, blood vessels developed on the surface, but milt does not yet flow out when the spermatic canals are pressed (Figure 2, upper right).

Grade 3. Thicker, blood vessels further developed, milt flows out when spermatic ducts are pressed (Figures 1 and 2, upper left).

See figures 1 and 2. Examples of gonads of each grade are preserved in formalin at the Palao Tropical Biological Station.

[TN: Figure 1 has the following captions.]

Figure 1 Showing the lack of correlation between size of gonads and the degree of maturity.

Upper right - Testis from a fish weighing 3.06 kg. Gonad is 17.5 cm long and weighs 55 g.

Upper left - Ovary from a specimen weigning 3.45 kg. The gonad is 16.5 cm long and weighs 80 g.

Lower left - Testis from a specimen weighing 5.66 kg. Length 22 cm, weight 185 g.

Lower right - Ovary from a specimen weighing 5.64 kg. Length 24 cm, weight 245 g.

[Captions on Figure 2]

Figure 2 Some of the grades of maturity of gonads

Upper right - Testis from a specimen weighing 5.81 kg. Length 24.5 cm, weight 150 g. Grade 2.

Lower right - Ovary from a specimen weighing 5.32 kg. Length 22 cm, weight 135 g. Grade 2.

Upper left - Testis from a specimen weighing 7.62 kg. Length 25 cm, weight 290 g. Grade 3.

Lower left - Ovary from a specimen weighing 7.38 kg. Length 23.5 cm, weight 175 g. Grade 3.

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Fish from 14 schools were examined, the total number of specimens being 135. The weight range was from 1.8 kg to 8 kg. In all of the specimens examined the gonads were advanced in maturity to some degree, and they were all large enough so that the ovaries and testes could be readily distinguished by their outward appearance. With regard to this point the author is reminded that year before last in February and in May he examined at Shimoda in Shizuoka Prefecture the gonads of a number of skipjack in the same size range as those taken at Palao, that is from 2 to 7 kg in weight, and he found that in the skipjack landed at Shimoda the gonads were slender and were attached to the dorsal wall of the body cavity. They were not markedly developed and it was impossible to tell the ovaries and testes apart by their outward appearance. The gonads of the yellowfin tuna which at Palao are taken mixed in with skipjack, and which are the same size as the skipjack of the schools with which they are associated, are developed only to the degree found in the gonads of the skipjack taken at Shimoda. On the other hand the large specimens of yellowfin taken on the longlines of the Fisheries Experiment Station's tuna investigation boat have fairly mature gonads which show the same stage of development as the gonads of the skipjack taken in Palao waters. Thus a good basis for comparison is provided on this point.

The weights of the gonads ranged from 20 to 330 grams, an extremely wide range. Within the area covered by this investigation the weight of the gonads was a function

of the body weight, and the large fish had large gonads while the small fish had small ones. This fact is shown by figure 3, which is a graph of the logarithms of the gonad and body weights with the males and females plotted separately. As can be seen from the graph, no difference could be perceived between the gonad weights of male and female fish. When I called at the Nankō Fishing Company at Saipan on my way to Palao, I was told that, "The small fish have small eggs and the large fish have large ones." I wondered what they were talking about, but now my doubts have been cleared up by the realization that by "eggs" they meant the ovaries, and I have found that they were quite right.

There are some wide variations in the weights of the gonads as shown in figure 3. It is thought that the smaller variation in the case of fish of medium weight is due to the fact that there were few specimens in this size range, and the particularly great variation in the small specimens is thought to be the result of using logarithms. At any rate there is a wide variation. One wonders whether it may be due to inherent variations in the gonads themselves, or whether it may not result from lumping together in one graph specimens which may have been at different stages of maturity either because they were taken at different seasons or from different schools. Figure 4 was drawn on the basis of data from only those specimens which were taken at the beginning of the study (the middle of October) and at its end (the first part of December). As the figure shows, there was a tendency for the gonad weights of the specimens taken in December to be slightly larger than those of the fish collected in October. It is thought that in such a study the difference in the season at which the specimens were taken is one reason for the large variation. It cannot, however, be said that this increase in weight is due to the development of the gonads within a period of two months. Since nothing is known of the ecology of the skipjack which provided the material for study, it may well be that this merely indicates a difference in the sexual development of the schools. While the author was at Palao the schools which were fished in the adjacent waters were of three types, those consisting only of small skipjack, those consisting only of large skipjack, and those characterized by the admixture of yellowfin tuna of the same size as the skipjack, which might be of any size from large fish to small. An attempt was made to find out whether the variation is due to the difference in the schools from which the specimens were collected by plotting separately the correlation between the gonad weights and body weights of fish from three schools, but this experiment revealed no difference in the gonad weights among the three schools, and showed that the variation noted above is not due to the fish of the three schools having different sized gonads.

Next only females were selected which, according to the criteria described above, were in the low grades 1 and 2 or the high grades 3 and 4 of sexual maturity, and the correlation between their body weights and gonad weights was examined. The material used in the experiment was rather scanty, but the results showed no correlation between the progress of the maturation of the gonad and its weight. It is naturally to be expected that the gonads will increase in weight as they develop, but if this increase follows the general laws of growth it can be assumed that it will be sudden and marked at first and will thereafter become slower and slower. Therefore it is thought that the gonads collected for this study had already reached a certain degree of maturity and consequently their increase in weight was at a rate too small to be shown on the graph. Thus, of the large variation in the relation of gonad weight to body weight it can only be said that there was a seasonal difference in the material studied, and the reason for it cannot, unfortunately, be clearly established. It may also be thought that since there are considerable differences between the gonad weights of the individual fish, the correlation shown in figure 4 may have been arrived at by chance because of the small number of schools and individual specimens which were used.

An attempt was then made to find some correlation between the schools or the season and the degree of maturity as determined by the criteria described above. This investigation showed no marked change in the degree of maturation either as between schools or as between the different seasons. In all schools at all times from the middle of October to December the greatest number of females were of Grade 3 maturity, with Grade 2 next, and Grade 4 least numerous. Among the males those of Grade 3 were most numerous with Grade 2 following. With both males and females fish in Grade 1 were extremely rare, the only such specimens observed being one female of 2.55 kg and two males 2.14 and 3.12 kg taken on October 30 from a school which consisted entirely of small fish. Even from this school a female which weighed 2.86 kg and showed Grade 4 maturity and a male of Grade 3 which weighed 2.61 kg were taken. In the latter part of October when I first examined the gonads of skipjack at Palao, I was surprised to see for the first time these organs in a somewhat advanced state of maturity, my only previous experience in the matter having been a few observations made in Shizuoka Prefecture. When I went aboard a skipjack boat at that time the captain told me, "The skipjack's eggs get large two times in the year, in November and in May." I waited with great expectations thinking to myself that if the gonads were so far advanced at this time, I should be able to collect plenty of thoroughly ripened ones in November, but my hopes were dashed when November and the December came around and the degree of maturity showed no advance.

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Adding the results described above to the fund of knowledge in this field, I would like to make a few observations. It is generally supposed that the spawning grounds of the skipjack are in warm seas, but when it comes to the point of where and when the skipjack of the tropics spawn we find a variety of opinions held by different individuals.[1] One opinion has it that they spawn all the year round, while others think that there is a spawning season. In the case of these latter, however, even for the waters adjacent to Palao different individuals have differing opinions about when the season is. No conclusions on this point can be drawn from the results reported in this paper, but since the maturity of the gonads remains at almost the same level from October to December without any fluctuations during that period it can be supposed that perhaps they remain at about this same stage of development throughout the year. Some points which agree with this hypothesis are: (1) In Japan the top-minnows [medaka] have ripe gonads in the spring and summer, but if they are brought to the tropics they can spawn all year round.[2] Furthermore frogs which in Japan spawn only in the spring can be found with ripe gonads all the year round at Palao. It is thought that temperature causes remarkable changes of various sorts in these physiological factors. (2) Skipjack which have ovaries in a rather advanced state of maturity are found the year round at Borneo and elsewhere. A comparison of the opinions of those who believe that the skipjack at Palao have a definite spawning season makes one wonder whether that season does not extend throughout the year. Assuming this to be true, and judging by the fact that I was unable to find any immature gonads like those which I had obtained in Shizuoka Prefecture, and since it cannot be thought that the individual fish within a school vary in the degree of their sexual maturity, the fact that from October through December the gonads remained at the same level of ripeness seems to indicate, not that the skipjack remain permanently at Palao but that only schools of fish which

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[1] "Symposium on the Spawning Grounds of the Skipjack and Tuna," South Sea Science, Vol.4, No.1 [POFI Translation No. 16].

[2] The writer has been able to get ova from top-minnows in Japan in December by keeping them at 25°C.

have gonads at the same stage of maturation are continually coming into the waters adjacent to Palao.[3,4] This is still a hypothesis, and in order to prove or disprove it one would have to study the differences in the individual gonads within the schools and the variations as between schools by examining a large number of specimens throughout one whole year. The opinion which the author has reached from the results reported in this paper is that if the annual changes in the degree of ripeness of the gonads could be ascertained in every area where skipjack are taken, some clarification of the problems of the location of spawning grounds and the migrations of the species would be attained.

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[3]This point is not limited in its application to the skipjack which are taken in a fairly advanced stage of maturity.

[4]While at Palao I heard that skipjack with ripe ova are found in the waters of the Tokobe and Celebes areas. I waited for an opportunity to investigate this interesting report, but was unable to do so. On my return trip in January of this year when I stopped at Saipan I was able to collect the ovaries of two skipjack. From the size of the organs I judged that they were from medium-sized fish and the person from whom I obtained them confirmed this judgment. The maturity of both specimens was of Grade 2.

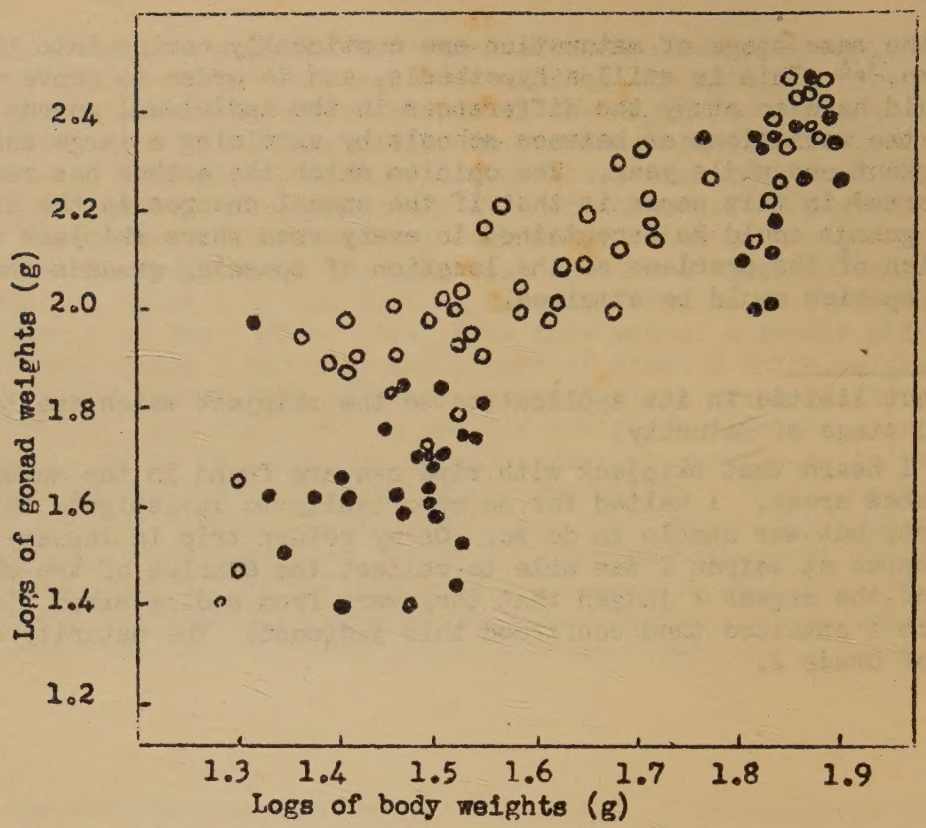

Fig.4 Variation between gonad weights of skipjack taken in mid-October and early December.
● mid-October ○ early December

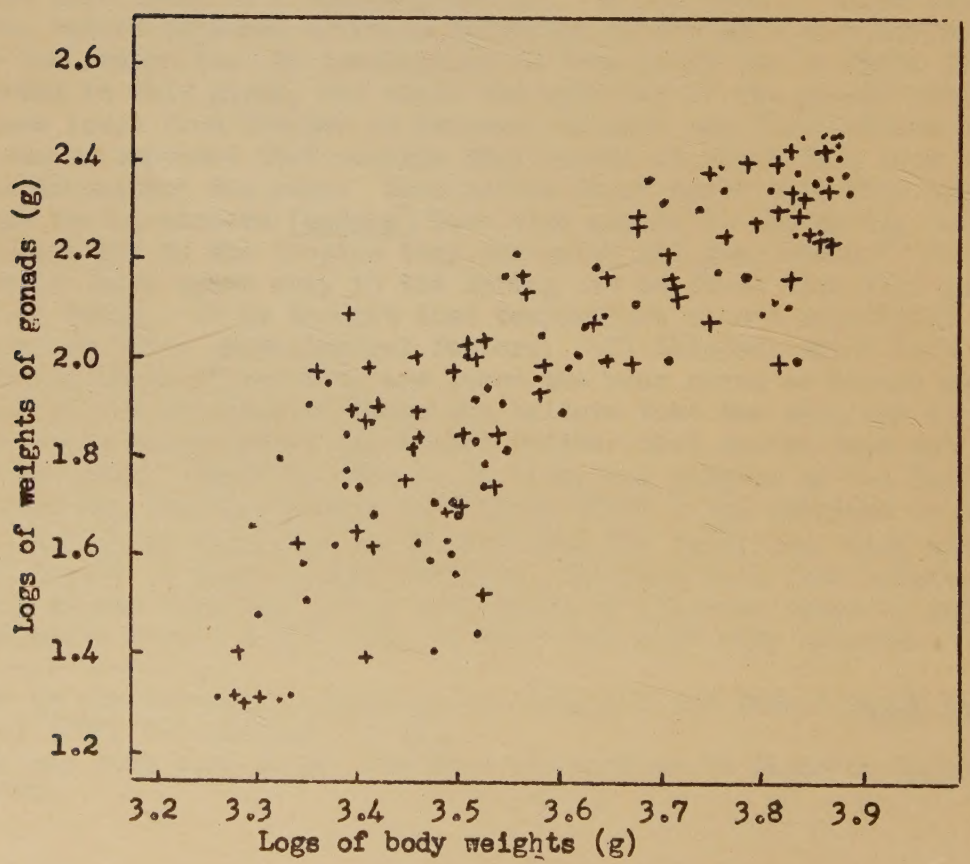

Fig.3 Correlation between gonad weights and body weights of skipjack. • males + females